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Adam Brinker, Joe Parcell, and Kevin Dhuyvetter

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Brinker is a graduate student in the Department of Agricultural Economics at the University of Missouri, Parcell is an associate professor in the Department of Agricultural Economics at the University of Missouri, and Dhuyvetter is a professor in the Department of Agricultural Economics at Kansas State University. Please direct correspondence to Joe Parcell at parcellj@missouri.edu.

Cross-Hedging Distillers Dried Grains:
Exploring Corn and Soybean Meal Futures Contracts

Ethanol mandates and high fuel prices have led to an increase in the number of ethanol plants in the U.S. in recent years. In turn, this has led to an increase in the production of distillers dried grains (DDGs) as a co-product of ethanol production. DDG production in 2006 is estimated to be near 11 million tons. A sharp increase in ethanol production and thus DDGs is expected in 2007 with an increase with the number of ethanol plants. As with most competitive industries, there is some level of price risk in handling DDGs and no futures contract available for this co-product. Ethanol plants, as well as users of DDGs, may find cross-hedging DDGs with corn or soybean meal (SBM) futures as an effective means of managing risk. Traditionally, DDGs are hedged using only corn futures.

Introduction

Ethanol mandates and high fuel prices have led to an increase in the number of ethanol plants in the U.S. in recent years. In turn, this has led to an increase in the production of distillers dried grains (DDGs) as a co-product of ethanol production. U.S. ethanol production has increased from less than 200 million gallons in 1980 to nearly 4,500 million gallons in 2006. The corn used for ethanol production has increased from less than 100 million bushels to 1,800 million bushels over that same time period (Iowa Corn Growers Association, 2006). One bushel of corn (56 lb.) yields approximately 2.8 gallons of ethanol and 17 pounds of DDGs in the process of ethanol production (American Coalition for Ethanol). Thus, DDG production in 2006 is estimated to be near 11 million tons. Ethanol production and therefore DDG production has been increasing from 1999 to 2005 as shown in Figure 1. Production is expected to increase dramatically over the next several years due to renewable fuels mandates.

The number of ethanol plants under construction and expanding has increased nearly 150%, raising production over 215% from January 2006 to January 2007 as shown in Figure 2. DDG production will also show an increase of nearly the same percentages. As with most competitive industries, there is some level of price risk in handling DDGs and no futures contract available for this co-product. Ethanol plants, as well as users of DDGs, may find cross-hedging DDGs with corn or soybean meal (SBM) futures as an effective means of managing risk.

Although DDGs in the U.S. are primarily composed of the product left over from corn ethanol production, DDGs and corn are not perfect substitutes. The protein content of corn, SBM, and DDGs varies considerably at 8-9.8%, 48%, and 27-28% respectively. Thus, a combination of corn and SBM contracts should provide a better risk abatement in hedging DDGs.

For the current analysis, statistical tests conducted for the presence of non-stationarity yielded no need to take the first differences. In addition, scouring the data indicated many similar DDG prices in the sequence. Therefore, the remainder of the analysis is described using levels as opposed to changes. Alternatively, Myers and Thompson find only a marginally improved hedge coefficient by employing first differences.

Much of the DDGs produced from ethanol production are used in ruminant animal diets, using up to 20% in the daily diets of cattle. Because DDGs can serve as a substitute for either grain corn or SBM (Powers et al.) the hedging weight between corn and SBM futures is nuclear. Since feed costs are the primary expenditure for these operations, being able to manage this risk is important to livestock producers. The objective of this study is to determine the appropriate hedge ratio of corn or SBM futures as an effective means of managing the risk associated with the price of DDGs.

Following from the hedging research of Brorsen, Buck, and Koontz and Franken and Parcell, time series weekly DDG cash price data (1990-2005) from four locations across the U.S. will be regressed on corn and SBM futures prices. In sample forecasted errors from the estimated hedging relationship will be used in the hedging weight procedure presented by Sanders and Manfredo to estimate weighted hedging values between corn and SBM futures and cash DDG price.

Managing risk is becoming a more important factor in agricultural production as this industry becomes more competitive. With no futures contract for the DDGs, finding a commodity to cross-hedge with and determining the size of the offsetting futures position for that commodity is important to the bottom line for producers. This study examines corn and SBM futures as possible cross-hedging commodities and evaluates their effectiveness across multiple time horizons.

Empirical Model

The empirical model is based off of the Sanders and Manfredo, 2004 research except that cash and futures prices are not first differenced.

As stated by Leuthold, Junkus, and Cordier, 1989, ex post minimum variance ratios are usually estimated with ordinary least squares regression as shown:

$$\Delta CP_t = \alpha + \Delta\beta FP_t + e_t \quad (1)$$

where CP_t and FP_t are cash price and futures price, respectively. In this equation, α is the trend in cash prices, β is the ex post minimum variance hedge ratio, and e_t is the residual basis risk. The R^2 from the above equation, a measure of hedging effectiveness, is used to evaluate other hedging instruments. These R^2 do not tell if the different hedging instruments are statistically greater in regards to risk reduction.

If there are two competing contracts that can be used to hedge a cash transaction, a standard minimum variance regression can be utilized to determine the hedging effectiveness of the two different contracts. Equation (1a) represents the original contract and equation (1b) represents the alternative contract.

(1a) $$CP_t = \alpha_0 + \beta_0 FP_t^0 + e_{0,t},$$

or

(1b) $$CP_t = \alpha_1 + \beta_1 FP_t^1 + e_{1,t}.$$

The fitted values for the competing hedging contracts are represented by y_0 and y_1 for equations (1a) and (1b) respectively. The dependent variable is represented y. The fitted and actual dependent variables can be plugged into equation (2) (Maddala, 1992, p. 516):

(2) $$y - y_0 = \Phi + \lambda(y_1 - y_0) + v.$$

The $y - y_0$ represents the residual basis or spread risk of the first model while $y_1 - y_0$ represents the difference in fitted values of the two models. This study is not looking at a conventional basis but is rather looking at a spread in the case of a cross hedge. In this case, if λ is not shown to be different from zero, then the second model has no more explanatory power than the first. Therefore, if $\lambda = 0$, the new contract does not at provide a reduced basis or spread risk above the original contract. According to Granger and Newbold, 1986, by adding λy to equation (4), it can be shown that:

(2a) $$y - y_0 = \Phi + \lambda[(y - y_0) - (y - y_1)] + v.$$

In this equation, $y - y_0$ is the residual basis risk for the original contract and $y - y_1$ is the residual basis risk for the new contract. Given the above, the error terms from equations (1a) and (1b) can be can be substituted for $y - y_0$ and $y - y_1$, in equation (2a) respectively, for basis risk.

(2b) $$e_{0,t} = \Phi + \lambda[(e_{0,t} - e_{1,t})] + v_t.$$

Equation (2b) is similar to the regression test for forecast encompassing by Harvey, Leybourne, and Newbold, 1998. In this equation, λ is the weight to be placed on the new model and $(1- \lambda)$ is the weight to be placed on the original model's forecast which minimizes the mean squared forecast error. The null hypothesis that the preferred model "encompasses" the new model is tested and the following are the alternative results.

$\lambda = 0$: A new model cannot be constructed to reduce the from the two series that would result in a lower squared error than the original model.

0<λ <1: A combination of hedging should be done in each market with λ as the weight assigned to the new futures contract.

λ = 1: All hedging should be done in the competing futures market.

As shown by Maddala (1992, p. 516), the λ that best reduces the error or risk can be illustrated as:

(3a)
$$\lambda = \frac{\sigma^2 e_0 - \rho e_0 e_1}{\sigma^2 e_0 + \sigma^2 e_1 - 2\rho e_0 e_1 \sigma e_0 \sigma e_1}.$$

Here, σ^2, σ, and ρ represent the variance, standard deviation, and correlation concerning basis risk for the original and new models. Maddala also shows:

(3b)
$$\lambda \geq 0 \text{ iff } \frac{\sigma e_0}{\sigma e_1} \geq \rho e_0 e_1,$$

and

(3c)
$$\lambda < 0 \text{ iff } \frac{\sigma e_0}{\sigma e_1} < \rho e_0 e_1.$$

The λ in equations (3b) and (3c) show the ability of the new futures contract to reduce the residual basis risk associated with the original futures contract.

Previous studies, as the above outline from Sanders and Manfredo, 2004, compare two different markets to determine the hedging effectiveness of each. This study will determine the cross hedge ratio of corn and SBM as an effective hedge for DDGs in four markets in different parts of the U.S.

The conventional practice of hedging corn in the corn futures markets is to use one 5,000 bushel contract for each 5,000 bushels of corn to be hedged. However, since DDGs is a substitute for corn or soybean meal the one-to-one ratio may be inappropriate, and a cross-hedge ratio necessary to determine the size of the futures position to take. Following the work of Buhr and Schroeder and Mintert, the relationship between cash prices for DDGs and corn or soybean meal futures prices is estimated using SHAZAM 9.0 to determine the cross-hedge ratio (β) in equation (1):

(4) DDG *Cash Price* = $\beta_{0,\,Corn}$ + $\beta_{1,Corn}$ *(Corn Futures Price)*,

and,

(5) DDG *Cash Price* = $\beta_{0,SBM}$ + $\beta_{1,SBM}$ *(Soybean Meal Futures Price)*,

where ($\beta_{0,\,Corn}$ and $\beta_{0,\,SBM}$) is the intercept or expected basis. The corn and soybean meals futures prices are for the nearby months. While not specified in equations (4) and (5), contract dummy variables were used to tease out across contract bias in the data. Unlike prior research, the estimated cross-hedge coefficients here are not time variant. In practice, merchandiser and procurement managers prefer to have a seemingly simple rule-of-thumb to use.

Historical weekly CBOT corn and soybean meal data were pulled for the time period from 1990 to 2005. Weekly DDG prices for four locations: Atlanta, Georgia; Boston, Massachusetts; Buffalo, New York; and Chicago, Illinois were collected for the same time period from historical Feedstuffs magazine prices.

Equation (4) or (5) utilizes the cross-hedge ratio ($\beta_{1,\ Corn}$ and$\beta_{1,\ SBM}$) to determine the approximate tons of ethanol to hedge.

$$(6) \qquad \textit{Cash Quantity Hedged} \qquad \frac{\textit{Futures Contract Quantity}}{\beta}\ .$$

The *Futures Contract Quantity* is the bushel (ton) amount per corn or soybean meal futures contract, and the *Cash Quantity Hedged* is tons of ethanol hedged per futures contract. For example, a 5,000 bushel (140 ton) corn futures contract would be appropriately cross-hedged against 140 tons of DDGs if the cross-hedge ratio ($\beta_{1,\ Corn}$) is determined to be 1.0. Similarly, if the cross-hedge ratio was estimated to be 0.8, the appropriate number of tons to cross-hedge against one corn futures contract is 175 tons (= 140 tons/0.8).

In practice, however, DDG merchandiser and procurement persons are more likely interested in how many futures contracts are needed per portion of DDGs produced during a particular time period. Rearrange equation (6) to get*,*

$$(7) \qquad \textit{Futures Contracts Held} = \textit{Cash DDG Quantity Hedged} \times \beta.$$

Suppose the cross-hedge ratio for corn futures is 0.80 and there is 140 tons of corn to a corn futures contacts, then for 525 tons of DDGs seeking to be hedged a merchandiser would take a position on three corn futures contracts (525*0.80/140).

Equation (7) can easily be specified to account for hedging weights assigned across multiple futures contract for the cash price of one commodity.

Results

Table 1 through Table 4 show the results of the model for each of the four locations. Panel A presents hedge ratios for corn and SBM to be used when hedging DDGs, along with statistical measures for the regression equations. The estimated hedge ratios for the four locations are similar in value with very little variation in both the corn and soybean hedge ratios. Corn and soybean hedge ratios varied by 0.062 and 0.054 respectively.

Panel B shows the estimated hedge weight to be placed on SBM with the standard error presented underneath. The estimated hedging weights on SBM did, however, show more variation across locations. The hedging weights varied nearly 0.200 between Buffalo and Chicago, raising the issue of why such a large variance between locations.

Panel C shows the number of CBOT contracts to hedge per given value of DDGs produced in a week. The 1,000, 2,000, 4,000, and 6,000 tons of DDGs correspond to approximately 17, 34, 69, and 103 million gallon per year (MGY) size ethanol plants.

Results here indicate the inclusion of SBM futures in the cross-hedge decision effectively reduce the hedging risk. The SBM futures contract helps explain variation in the (DDG – Corn futures) spread not picked up by the corn futures price. This shows the importance of including the alternative contract of SBM in addition to the corn futures.

Hedging Weight Changes Over Time The flexible least squares (FLS) estimator is used to test for cross-hedge parameter stability over time. The FLS estimator detects parameter instability which may indicate possible structural change in the analyzed variable (Tesfatsion and Veitch; Lutkepohl; Dorfman and Foster; Parcell; and Poray, Foster, and Dorfman). Graphically depicting how the cross-hedge estimate changes over time can be useful in assessing structural change, and the FLS estimator allows for such a graphical representation. The graphical representation suggests inferences regarding potential structural changes that may cause the cross-hedge estimate to change temporarily or persistently.

A brief description of the FLS estimator is given here. Assume a simple hedging model like the following:

$$CP_t = \beta FP_t + \varepsilon_t, \tag{8}$$

where CP_t is the cash price at time *t* (*t* = 1,…,T), FP_t is futures price at time *t*, and ε_t is a random disturbance term. By allowing the coefficient β to vary over time, the FLS estimator minimizes the loss function derived from (8), which can be specified as:

$$\sum_{t=1}^{T}(CP_t - \beta_t FP_t)^2 + \lambda\sum_{t=1}^{T-1}(\beta_{t+1} - \beta_t)' \mathbf{D} (\beta_{t+1} - \beta_t), \tag{9}$$

where β_t is a {T x 1} vector of time-varying parameter estimates, λ is a value between zero and one [$\lambda \in (0,1)$], and **D** is a {T x T} weighting matrix. The first term is the sum of the squared errors. The second term is the sum of the squared parameter variations over time. The matrix **D** is specified as a positive definite diagonal unit matrix with diagonal elements d_{ii} = 1. Given the specification of (9), a large λ penalizes parameter variability and a small λ allows for greater parameter variability.

The FLS was used to graphically represent the time path of the SBM cross-hedge weights. Although the individual FLS parameter estimates do not hold great explanatory power, the change in magnitude of the coefficients over the time period specify the impact of structural change.

Figure 3 through Figure 6 show the time path of the SBM hedge weight for $\lambda = 1$ for the four locations. SBM cross-hedge weights varied substantially from 1990 to the end of 2001. From 2002 forward, the variability of SBM hedge weight seemingly decreased for all locations except Boston in terms of absolute value. Variability is even less for the 2005 time period as ethanol production began increasing at a faster pace as shown in Figure 2. It is clear that SBM cross-hedge weights have decreased in magnitude for the majority of locations; much of this change can be attributed to the increased substitutability between corn and DDG in some livestock rations. The results indicate the SBM hedge weight may continue to decline to the point of no weight. Further research is needed to address this issue.

Conclusions

The co-product of ethanol, distillers dried grains (DDGs) are a product with nutritional (protein) content between that of corn and soybeans. Thus, it makes sense to use a combination of both corn and SBM to hedge against the corn derivative product, DDGs. Analysis shows that approximately 20-40% of the hedging weight for DDGs is placed on SBM with the remaining going to corn.

Even though DDGs are the derivative product of corn, their makeup and composition put them in a category for end use that is closely related to SBM. This study suggests that a combination of both corn and SBM futures contracts provide provides a hedge that better reduces the spread risk of cross-hedging DDGs.

Only four locations were used for cash DDG prices in this study. Data acquisition for DDG price data is difficult to obtain for any substantial length of time. More locations report prices, but no consistent historical data could be found. As DDGs become a more widely used and traded commodity, DDG price data should become more readily available.

There has been considerable structural change in ethanol production capacities over the last four to five years of this sample period. From 1990 to 2002, there was relatively little ethanol production in the U.S. Ethanol production nearly doubled from 2005-2006 and tripled from 2006-2007. Thus, the impact of a change in ethanol production capacity has caused the SBM hedge-weight to become lower in absolute value.

There are many research areas that could build off this study. For example, instead of just looking at the nearby futures contracts for DDG prices, alternative hedging horizons could be explored for better hedging effectiveness.

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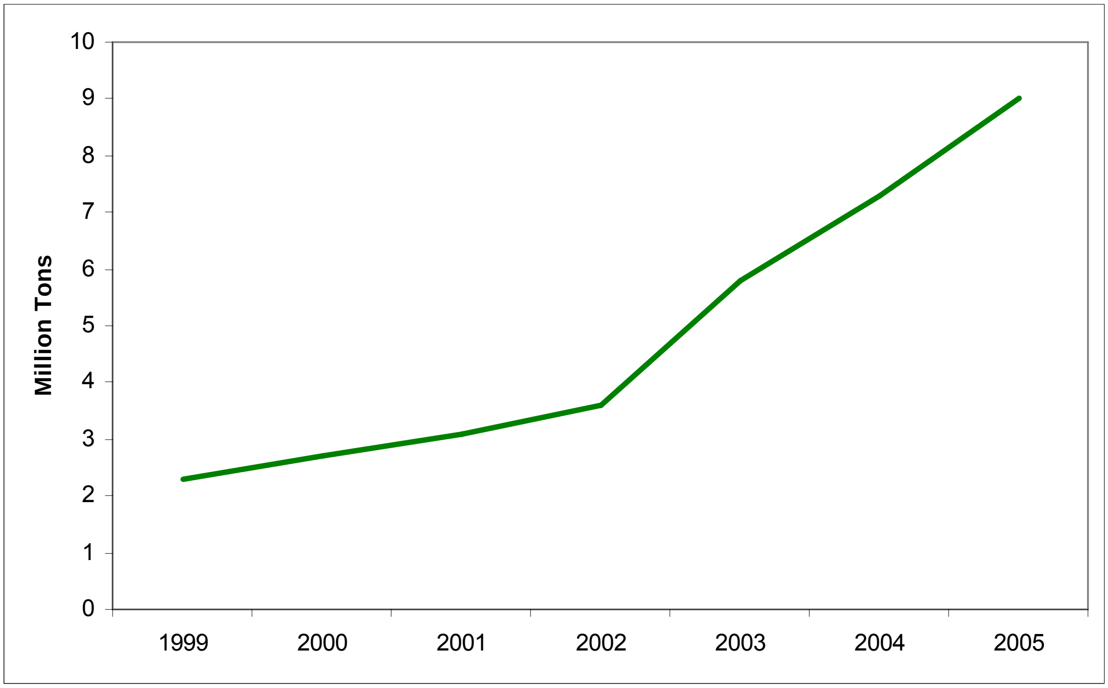
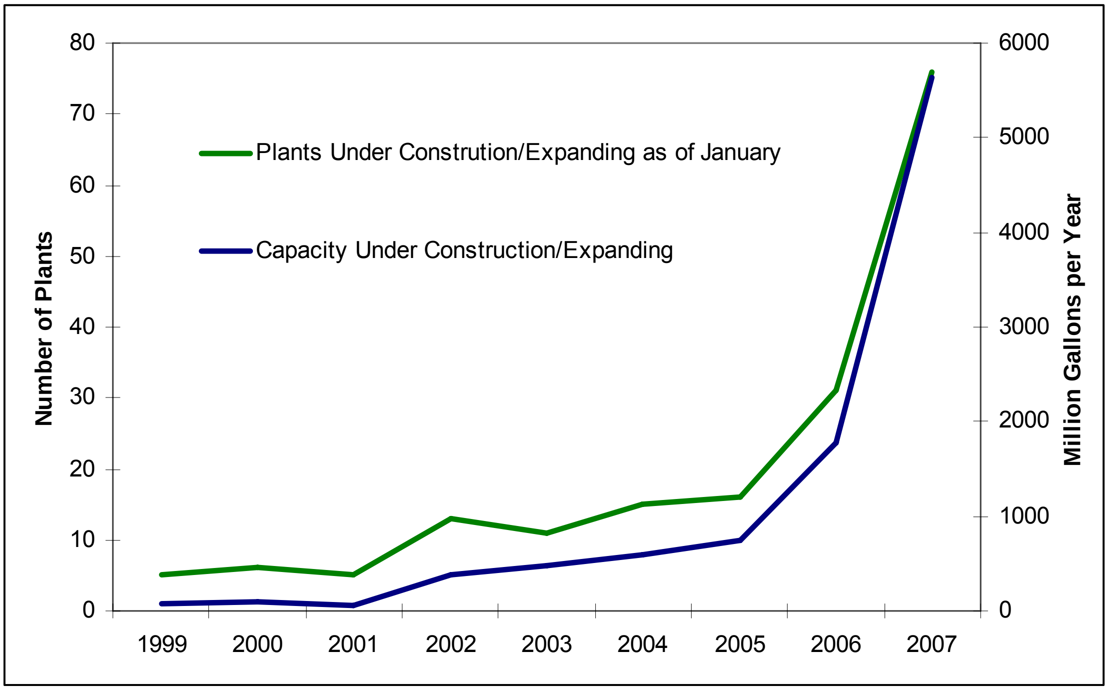
Figure 1. Historic Distillers Grains Production from U.S. Ethanol Refineries



Source: Renewable Fuels Association

Figure 2. Ethanol Plants Under Construction/Expanding and Increased Capacity as of January



Source: Renewable Fuels Association

Figure 3. Time Path of SBM Cross-hedge Weight for Atlanta, $\lambda = 1$

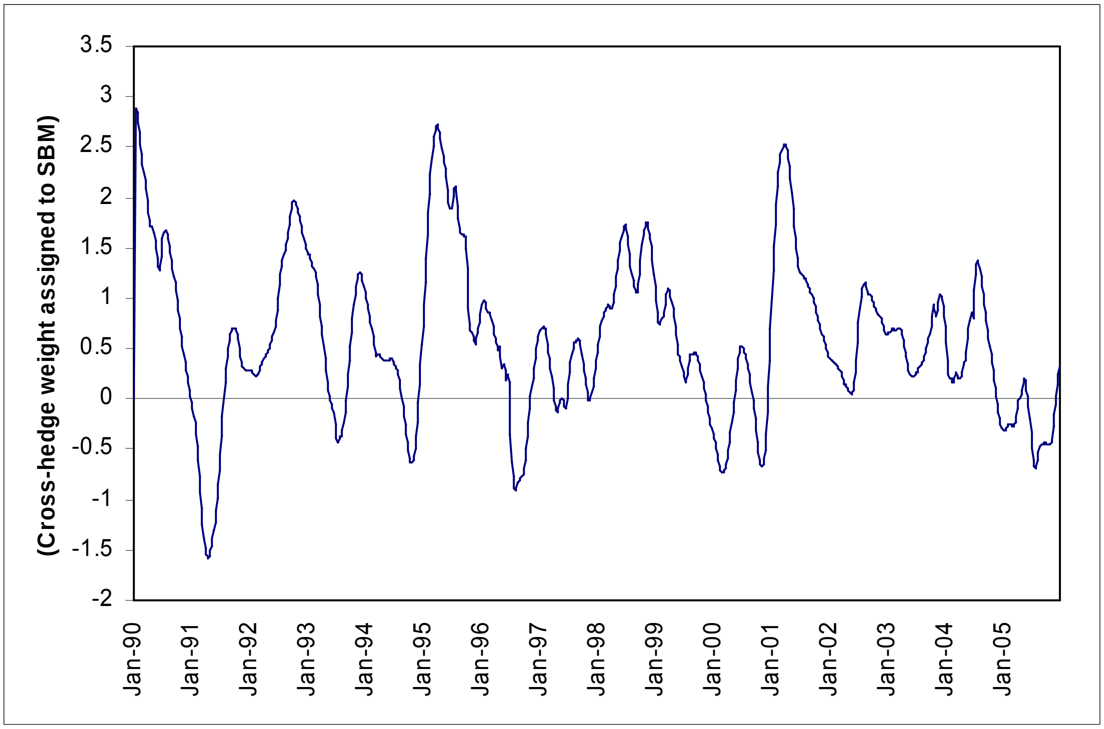


Figure 4. Time Path of SBM Cross-hedge Weight for Boston, $\lambda = 1$

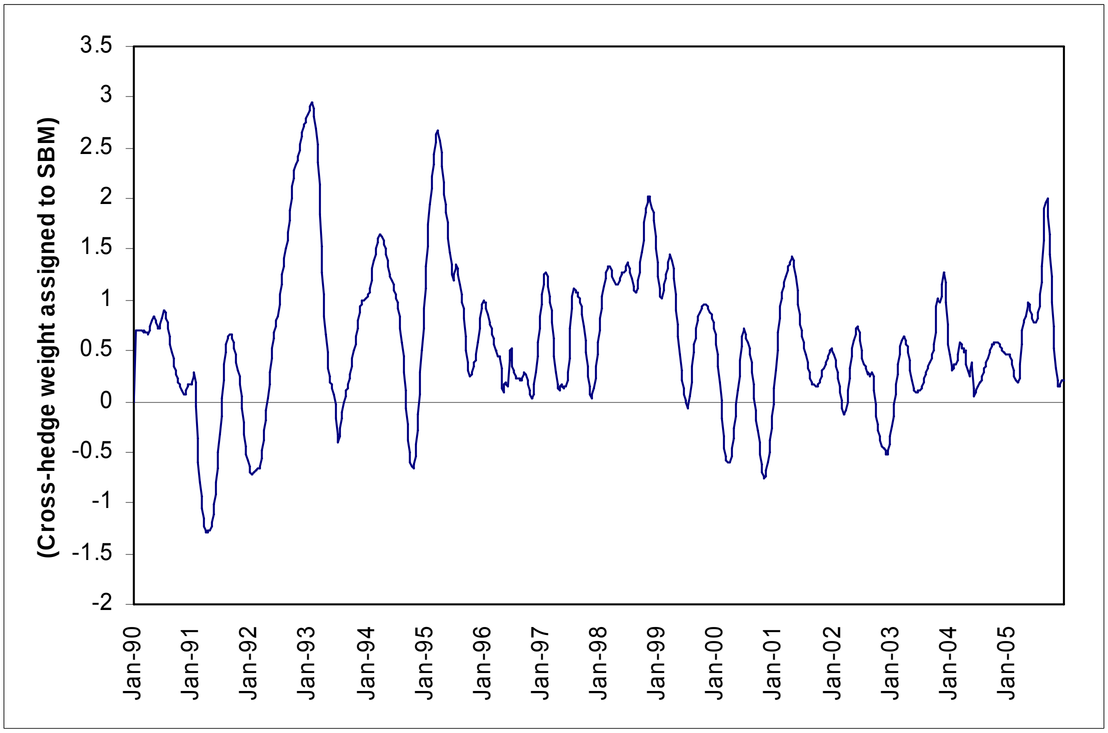


Figure 5. Time Path of SBM Cross-hedge Weight for Buffalo, λ = 1

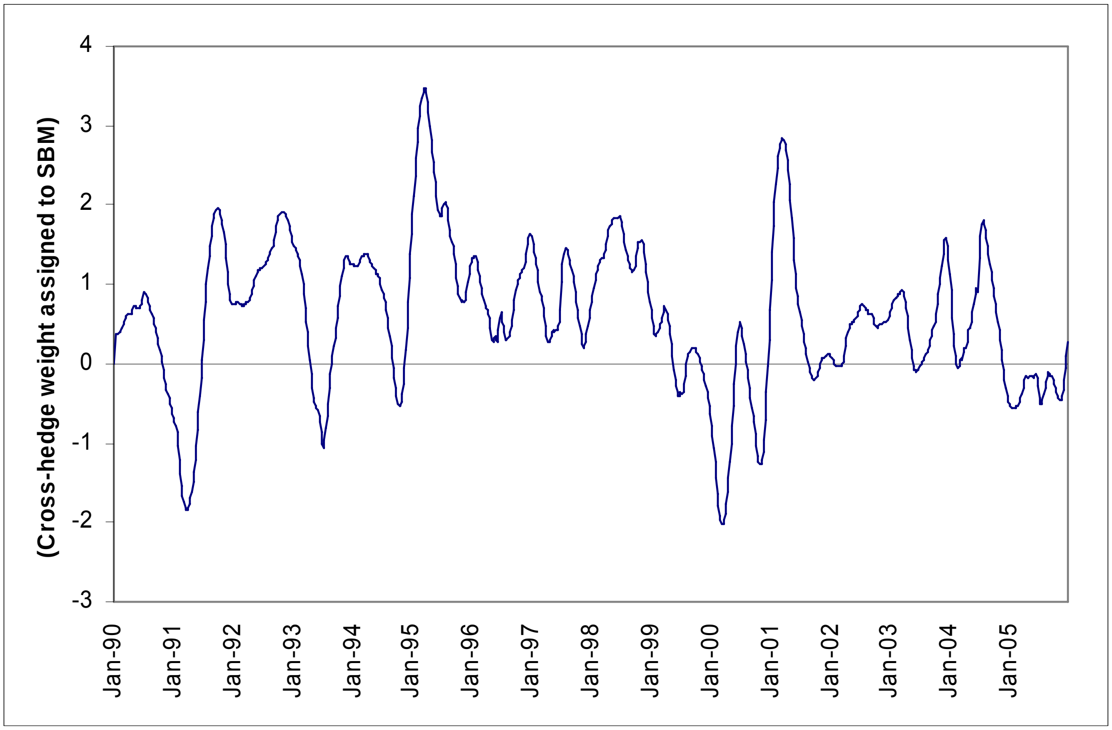


Figure 6. Time Path of SBM Cross-hedge Weight for Chicago, λ = 1

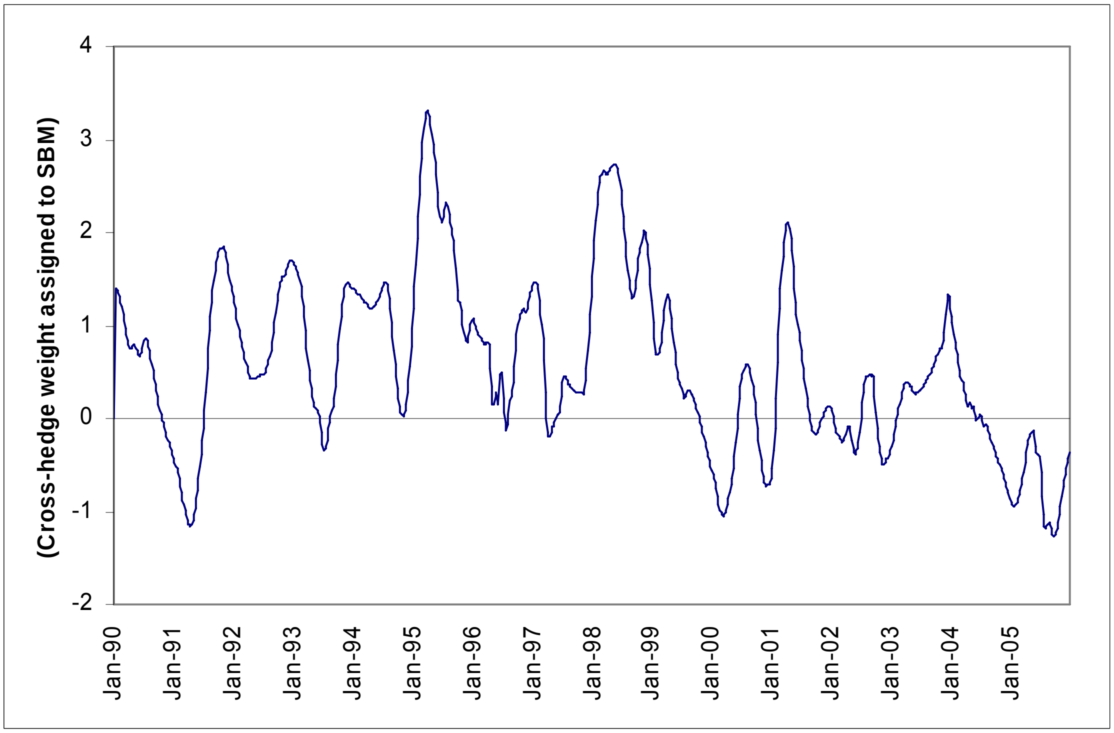


Table 1. Atlanta Market

Panel A. Hedging Regressions

Description	Corn	SBM
Nondelivery Months Estimated Hedge Ratio (B)	0.986	0.419
(Standard Error)	(0.032)	(0.015)
R^2	0.616	0.459
Standard Deviation (e_t)	-0.014	-0.107
Correlation ($\rho e_0 e_1$)	0.546	

Panel B. Encompassing Regression

Description	Corn	SBM
Estimated Hedging Weight		0.311
(Standard Error)		(0.006)

Panel C. Contracts Required to Hedge

	Weekly DDG Output (tons)			
	1000	2000	4000	6000
Contracts used to hedge quantity				
CBOT Corn	4.853	9.705	19.410	29.115
CBOT SBM	1.303	2.606	5.212	7.819

Table 2. Boston Market

Panel A. Hedging Regressions

Description	Corn	SBM
Nondelivery Months Estimated Hedge Ratio (B) (Standard Error)	0.985 (0.039)	0.466 (0.017)
R^2	0.533	0.462
Standard Deviation (e_t)	0.162	-0.123
Correlation ($\rho e_0 e_1$)	0.612	

Panel B. Encompassing Regression

Description	Corn	SBM
Estimated Hedging Weight (Standard Error)		0.380 (0.008)

Panel C. Contracts Required to Hedge

	Weekly DDG Output (tons)			
	1000	2000	4000	6000
Contracts used to hedge quantity				
CBOT Corn	4.362	8.724	17.449	26.173
CBOT SBM	1.771	3.542	7.083	10.625

Table 3. Buffalo Market

Panel A. Hedging Regressions

Description	Corn	SBM
Nondelivery Months Estimated Hedge Ratio (B)	1.047	0.446
(Standard Error)	(0.038)	(0.017)
R^2	0.550	0.478
Standard Deviation (e_t)	-0.531	-0.788
Correlation ($\rho e_0 e_1$)	0.581	

Panel B. Encompassing Regression

Description	Corn	SBM
Estimated Hedging Weight		0.407
(Standard Error)		(0.008)

Panel C. Contracts Required to Hedge

	Weekly DDG Output (tons)			
	1000	2000	4000	6000
Contracts used to hedge quantity				
CBOT Corn	4.435	8.870	17.739	26.609
CBOT SBM	1.815	3.630	7.261	10.891

Table 4. Chicago Market

Panel A. Hedging Regressions

Description	Corn	SBM
Nondelivery Months Estimated Hedge Ratio (B)	0.987	0.412
(Standard Error)	(0.040)	(0.186)
R^2	0.527	0.332
Standard Deviation (e_t)	0.323	-0.183
Correlation ($\rho e_0 e_1$)	0.702	

Panel B. Encompassing Regression

Description	Corn	SBM
Estimated Hedging Weight		0.210
(Standard Error)		(0.004)

Panel C. Contracts Required to Hedge

	Weekly DDG Output (tons)			
	1000	2000	4000	6000
Contracts used to hedge quantity				
CBOT Corn	5.570	11.139	22.278	33.417
CBOT SBM	0.865	1.730	3.461	5.191